



# Stratospheric Observatory for Infrared Astronomy (SOFIA)

Presented by

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# Outline

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# SOFIA Description



## Salient Features

- 2.5-meter, airborne telescope optimized for mid- to far-IR observations, mounted in 747SP
- Access to full spectral range from 0.3 to 1600  $\mu\text{m}$
- Range covered by numerous state-of-the-art focal plane instruments
- Stratospheric operation for over 6 hours per mission, 960 observing hours per year
- Diffraction limited beyond 10-15 microns
- Deployable for all-sky/opportunity coverage



## Implementation Characteristics

- Cooperative 25-year program with Germany under formal MOU
  - U.S.: Aircraft modification, onboard mission control system, ground support system, integration, FAA Certification, 80% of operations
  - Germany: Telescope Assembly, support for integration, 20% of operations
  - U.S. and Germany share telescope time in same proportion – 80:20
- Single prime contract for U.S. development and operations as a GOCO facility
- Science-led development and operations: prime contractor is USRA
  - Operations out of Moffett Field, CA, as proposed by USRA team
- Lead NASA Center: Ames Research Center

# SOFIA Team

- USRA: Project management; science operations
  - Raytheon – Waco: aircraft modification
  - United Airlines: aircraft operations
  - Sterling Software: software development, system administration
  - NASA Ames Research Center: work products (airfield operations, SSMOC, cavity door design, science products)
  - SASP Alliance: education & public outreach
  - University of California: science support
- Telescope Consortium
  - MAN Technologie – Gustavsburg (MAN-I): general project management and systems engineering; suspension assembly; inertial pointing control system; secondary mechanism
  - MAN Technologie – Karlsfeld (MAN-A): Nasmyth tube/metering structure; primary mirror cell
  - Kayser-Threde – Munich: Optics, cameras, tracking subsystem, electronics and software
    - REOSC: Primary and Tertiary mirror

# Science

- Major topics that SOFIA will address include:
  - Prebiotic conditions in the Early Solar System and in other planetary systems
  - Star and planet formation in the Galaxy and in other galaxies
  - Dynamics of the gas and dust around nearby black holes
  - Evolution of galaxies: starbursts vs. AGN
- SOFIA will provide a unique set of capabilities:
  - Access to and instrumentation for the entire infrared and submillimeter wavelength range
  - Sensitive spectroscopic measurements, covering a wide range of spectral resolutions
  - Excellent spatial resolution for imaging in the mid-infrared and beyond
- Data Cycle System (not currently in scope of program)
  - Work has begun to design a truly user friendly interface to General Investigators and provide for a scientifically useful archive

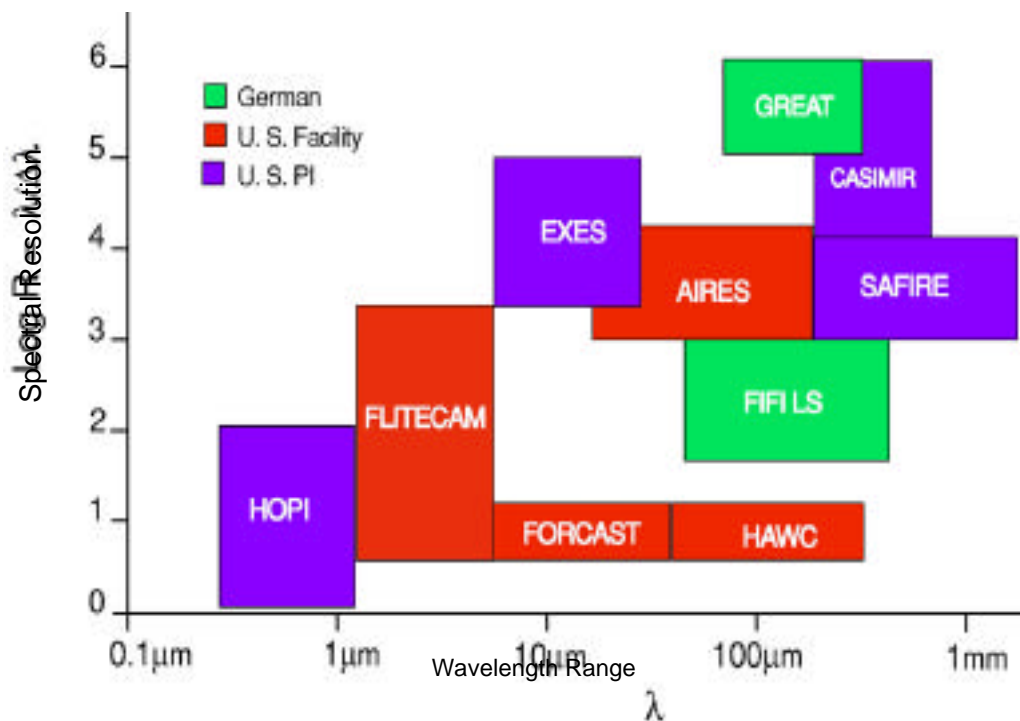
# SOFIA Science Instruments – Initial Complement

## FACILITY INSTRUMENTS

- Airborne Infrared Echelle Spectrometer (AIRES)  
PI: E. Erickson, Ames Research Center
- Near IR Test Camera (FLITECAM)  
PI: I. McLean, UCLA
- Far-Infrared Bolometer Camera (HAWC)  
PI: D. Harper, Yerkes Observatory
- Mid IR Camera (FORCAST)  
PI: T. Herter, Cornell University

## PRINCIPAL INVESTIGATOR INSTRUMENTS

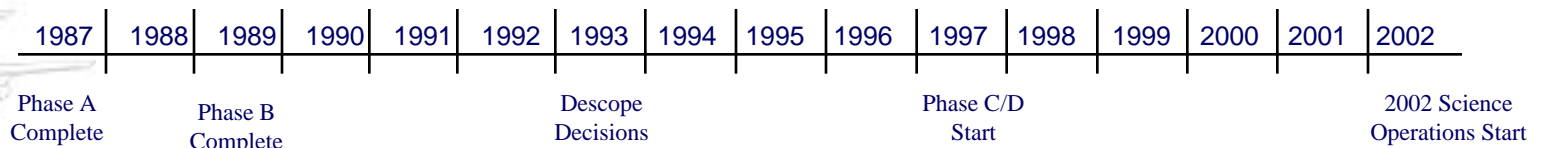
- Field Imaging Far IR Line Spectrometer (FIFI LS)  
PI: A. Poglitsch, MPE, Garching
- Heterodyne Spectrometer (GREAT)  
PI: R. Guesten, MPIfR, KOSMA, DLR-WS
- Visible Occultation CCD Photometer/Imager (HOPI)  
PI: E. Dunham, Lowell Observatory
- Echelon Spectrometer (EXES)  
PI: J. Lacy, University of Texas
- Submillimeter and Far-Infrared Experiment (SAFIRE)  
PI: S. Moseley, Goddard SFC
- Heterodyne Spectrometer (CASIMIR)  
PI: J. Zmuidzinas, Cal-Tech



# PCA: Level 1 Requirements

Requirement	Status
• Effective aperture dia.: 2.5 m	OK
• Elevation range: 20 - 60 deg.	OK
• Wavelength range: 0.3 - 1600 microns	OK
• Optical image quality: 1.5 arcsec – D(80%)	OK
• Image stability: 0.2 arcsec $R_{rms}$	Will not meet spec at start of operation; plan to upgrade to specification by 2005
• Operations: 6 hours at/above 41 kft	OK
• Operations: Access to SIs	OK
• Operations: 40 PI/GI teams/year	OK
• Operations: 1200 science hours yrs 1 + 2	OK
960 hours/yr thereafter	OK

## Major Program Milestones





# Image Stability Impact on Science & Plan for Upgrade

- Level 1 requirements:
  - Pointing stability
  - Optical image quality
  - Effective total image size
- Simulations by Consortium predict for start of operations:
  - Pointing stability
  - Optical image quality
  - Effective total image size

Rrms	D (80%)
0.2"	0.5"
0.6"	1.5"
0.63"	1.6"
1.1"	2.8"
0.4"	1.0"
1.2"	3.0"

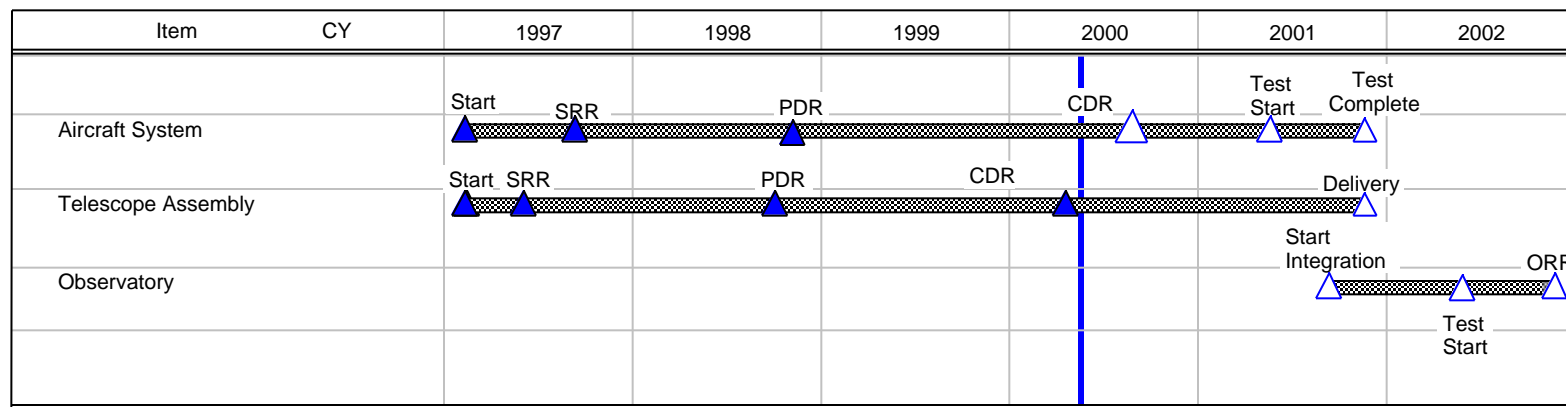
- Science impact almost entirely dependent on effective total image size
- Science impact of predicted image sizes evaluated by 8 PI teams using peer-reviewed science projects (16)
  - 14 of 16 projects can be carried out with minor increase in integration time
  - 1 of 16 projects can be carried out, but with substantial (x3) increase in integration time, so limited to brightest sources
  - 1 of 16 projects cannot be done
- EIRR concluded science still compelling and SOFIA should proceed into operations
  - Board also recommended combining Level 1 requirements on image motion + quality
  - Recommended that SOFIA proceed with study of upgrade in operations, but apply cost benefit trade before implementing



# Progress over Past Year

- Programmatic
  - Experienced, senior general project manager hired by MAN-I
  - DLR-Consortium negotiated and signed revised development contract – substantial cost increase shared by both parties
  - Observatory schedule replanned and firmed up (telescope, aircraft modification, Joint AITV); now maintaining schedule
- Technical
  - TA CDR complete with minor actions
  - Telescope system: primary mirror lightweighting complete; secondary and tertiary mirrors fabrication complete; bearing sphere casting complete; fabrication of critical long-lead items begun
  - Observatory system: Section 46 prototype testing complete; aero and structural modification models complete and validated; critical ICDs baselined; science operations scenarios finalized; software build 0 complete; incremental CDRs (bulkhead and structures); fabrication started on long-lead items

# SOFIA Program Milestone Schedule\*



\* Current schedule is included in revised PCA, which is pending approval.

Schedule reserve: Approximately one month on U.S. side and on German Side

Schedule assumptions: Joint AITV plan exercised

Observatory integration conducted in Germany

Highlights through CY01:

Observatory system CDR	8/00	Begin major TA subsystem tests	5/01
Primary polishing complete	10/00	Aircraft modification complete	8/01
Software final design review	11/00	Aircraft flight/certification tests complete	11/01
Joint integrated software testing	3/01	Start TA installation into aircraft	12/01

# SOFIA

A NASA  
Origins  
Mission

# SOFIA Education/Public Outreach

- Education Planned for Operations — Summary
  - *Airborne Ambassadors*
    - 200-300 educators each year
    - Pre-flight training
    - Active participation in missions
    - Supported with web-based and print classroom materials
    - National network of mentor educators and teacher trainers
  - *Education Partners Program*
    - Teachers integral with PI teams
    - Partnerships for SOFIA scientists and engineers with educators
  - *Science Literacy & Education program*
    - Seminars, flights for college astronomy and science education faculty from small, and/or minority colleges
  - *SOFIA EPO Interns & Fellows*
    - Science journalism internships for graduate students
    - Educator fellows from K-12 and colleges as EPO program staff
    - Science education internships for graduate students

# SOFIA Education/Public Outreach (Cont'd)

- Recent highlights

- *Public Outreach*

- United Airlines SOFIA Inflight Videos — 7 million viewers per month
    - Exhibits in development: National Air and Space Museum; Chabot Space and Science Center
    - Open House: Wings Over Moffett, US Space Shuttle Conference, Raytheon-Waco
    - Educator workshops at science teacher conferences, 8-10 per year, generating substantial interest

- *Science Outreach Support*

- SOFIA exhibit at AAS Chicago & Atlanta
    - Star Formation Workshop Bioastronomy Conference

- *Press & Broadcast Media*

- SOFIA events at UAL's Chicago partnership school
    - NASA HQ visit to Raytheon-Waco for open house
    - Mirror lightweighting milestone
    - New EPO staff to support press & media requests and contacts



*Open House at Raytheon-Waco*

For More Information about SOFIA, check out our Web Site at:

**<http://sofia.arc.nasa.gov>**

**Stratospheric Observatory for Infrared Astronomy** **SOFIA**

**Observatory** **Welcome to the SOFIA Homepage**

**Science**  
**Project**  
**Education**  
**News**  
**Image Gallery**  
**FAQ's**  
**Related Links**

NASA and the German space agency, DLR, are working together to create SOFIA - a Boeing 747-SP aircraft modified to accommodate a 2.5 meter reflecting telescope. SOFIA will be the largest airborne telescope in the world, and will make observations that are impossible for even the largest and highest of ground-based telescopes. The observatory is being developed and operated for NASA by a team of industry experts led by the [Universities Space Research Association](#) (USRA). SOFIA will be based at NASA's [Ames Research Center](#) at [Moffett Federal Airfield](#) near Mountain View, California, and is expected to begin flying in the year 2002. SOFIA is part of NASA's [Origins](#) Program.

[View the new First Light Instrument flyers!](#)



**NASA** **DLR**  
**USRA**